THE BANKER PONIES OF NORTH CAROLINA AND THE GHYBEN-HERZBERG PRINCIPLE*

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CHAPEL HILL

Off the coast of North Carolina, there is a sandy barrier reef which extends from lower Virginia southward to just south of Morehead City, North Carolina. As can be seen in Figure 1, the reef consists of a long peninsula which reaches from Back Bay, Virginia (which is just above the upper limit of the photograph) to Oregon inlet; Hatteras Island, including famed Cape Hatteras; Ocracoke Island; Portsmouth Island; and a series of smaller islands which are known as the Core Banks and the Shackleford Banks. Collectively, the peninsula and the islands are called the Outer Banks. The greatest distance from the mainland to the islands is approximately 30 miles. The average width of the reef is less than a mile. The elevation above sea level is less than 20 feet, with the exception of an area along the upper portion of the peninsula where there are sand dunes as high as 100 feet.

The surface of the reef consists of sandy areas interlaced with areas in which coarse grasses or marsh grasses predominate. Various species of dwarfed trees and myrtles are also present on the islands.

There are no freshwater springs or streams on the entire island chain of the reef. Until recent years, the human inhabitants used only rain water for drinking.

The subject of the presentation, the banker ponies, are feral horses which inhabit two areas of the Outer Banks, Ocracoke Island and the Shackleford Banks and environs. These horses are known to have inhabited the Outer Banks for at least two centuries, but how they arrived there remains unknown. Local lore has it that they swam ashore from Spanish galleons that were shipwrecked as they plied the North Carolina waters.

The ponies are smaller than horses of most domestic breeds. They vary in color and have long manes and tails. They travel in groups of 4–10, known as harems. A harem generally consists of one stallion and several mares and colts, although young stallions may edge along the periphery of the harem (see Figures 2, 3).

On the Shackleford Banks and smaller, more inland islands, they continue to live under wild conditions, ranging at will, but recently they

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FIG. 1. A photograph taken by the crew of Apollo IX showing the Outer Banks of North Carolina. Ocracoke Island is indicated by the upper arrow and the Shackleford Banks by the lower arrow.

Fig. 2. A harem of banker ponies.

Fig. 3. A larger harem of banker ponies.

have been fenced in by the National Park Service on Ocracoke Island as a consequence of a great increase in the number of tourists and campers visiting the island.

My particular interest in the banker ponies began several years ago when I received a letter from the late Doctor A. V. Wolf in which he inquired about the sources of drinking water for a "group of wild horses on the islands off North Carolina".

Doctor Wolf, as many of you know, was interested in the potability of sea water under various circumstances and had obtained hearsay evidence that wild goats and cattle on several islands in the Pacific Ocean drink sea water. One bit of evidence that Doctor Wolf had obtained came from an account by J. R. Slevin (1), a member of the crew of the schooner *Academy*, a vessel which was sent on a scientific expedition to the Galapagos Islands in 1905 by the California Academy of Sciences. Slevin observed that wild goats on Hood Island came down frequently to the ocean and drank sea water. He, of course, did not know the quantities of sea water they drank or whether they were drinking sea water for its salt content or for water.

Had they been ingesting large quantities of sea water, it would have been a remarkable feat, indeed. Let me remind you why this is the case. The solute concentration of sea water is about 3% and the osmolality is about 1200 milliequivalents/kg of water or milliosmols/kg of water. The major constituents of sea water are shown in Table 1. By far the most abundant ions are sodium and chloride.

A terrestial mammal who lives in an environment where sea water is the only source of water must be able to excrete these ions in the urine in concentrations equal to or greater than the concentrations in which they exist in sea water.

Although most mammals, under conditions of dehydration, are able to achieve urinary osmolal concentrations greater than 1200 mOsm/kg, it should be remembered that, under these circumstances, the urinary solute is mostly urea, and very little sodium is present.

TABLE 1
Major Constituents of Sea Water

Positive Ions	g/kg of Sea Water	mEq/kg of Sea Water	Negative Ions	g/kg of Sea Water	mEq/kg of Sea Water
Na	10.559	459.134	Cl	18.980	535.303
Mg	1.272	104.605	SO_4	2.649	55.146
Ca	0.398	19.857	HCO_3	0.139	2.285
K	0.380	9.712	Br	0.064	0.806
Sr	0.013	0.303	F	0.001	0.071
Sum	12.622	593.611	Sum	21.833	593.611

The pertinent information—that is the extent to which sodium can be concentrated in the urine—has been obtained from experiments in man and dog in which sea water or hypertonic solutions of sodium were administered. McCance and Young (2) gave 500 ml of 3.5% saline to normal human beings and repeated the procedure after three days of water deprivation. They found that the concentration of sodium in the urine reached as high as 322 mEq/L. Elkinton and Winkler (3) found that in dogs given small amounts of 5% solutions of sodium chloride for a 4–6 day period, the urinary sodium concentration reached a level as high as 712 mEq/L.

Thus the human kidney was not able to achieve urinary sodium concentrations as high as sea water and the dog kidney concentrations slightly above that of sea water.

But, in both sets of experiments, these concentrations were achieved only transiently.

Thus, the administration of salt solutions with sodium concentrations comparable to sea water in both experiments led to hypertonicity of the extracellular fluid and a loss of body water.

Although no information is available on the horse, the evidence from these experiments and others makes it unlikely that any terrestial mammal can live with sea water as its only source of water.

Nonetheless, the fact that the banker ponies have lived for years on the Outer Banks without any obvious source of fresh water led us to explore their environment further.

Studies of the sources of drinking water for the ponies were undertaken first on Ocracoke Island and subsequently on Bird Shoal-Carrot Island, a complex of islands lying slightly inland to the Shackleford Banks.

The first study was done at Ocracoke Island. At the time of the study, the ponies were living in the wild. A survey of the island confirmed that there were no fresh-water springs, streams, or lakes.

Although ponies were roaming throughout the island, none was seen during the act of drinking water. However, we were told by the natives of the island that ponies dig shallow holes from which they drink water. We, therefore, dug holes at various places on the island, and the results of our findings are shown in Table 2. Here is shown the osmolality of surface water taken from the ocean, from Albermarle sound, and from tidal flats, as well as the osmolality of water obtained from holes which I dug. It can be seen that the osmolality of the surface water is what one would expect. However, I was surprised to find such low osmolal concentrations of water obtained from such shallow holes so close to the ocean.

Some time later, I investigated the drinking water sources of the ponies living on the Bird Shoal-Carrot Island complex.

Here, too, I was told that the ponies dig holes and drink water therefrom. In contrast to the situation on Ocracoke, the evidence was there to see. Throughout the island complex, there are holes, such as the one shown in Figure 4 which vary in depth from 2½ to 4 feet.

The findings are shown in Table 3. Here are shown the osmolality and the sodium concentration of water taken from various sources.

TABLE 2

Osmolality of Samples of Water from Ocracoke Island

Specimen	Source of Water	Osmolality (mOsm/kg)
	Surface Water	
1	Ocean	960
2	Tidal flat	1147
3	Marshy area (? rainwater)	74
4	Sound	728
	Water Holes	
5	Hole dug by W.B.B. *ca.* 2½ feet deep	11
6	Hole dug by W.B.B. *ca.* 4 feet deep	12
7	Hole dug by W.B.B. *ca.* 2 feet deep	20
8	Hole dug by W.B.B. *ca.* 2 feet deep	14

FIG. 4. A water hole dug by ponies on Carrot Island.

TABLE 3

Osmolality and Na^+ Concentration of Samples of Water from Bird Shoal and Carrot Island

Specimen #	Source of Water	Osmolality (mOsm/kg)	Na^+ Concentration (mEq/l)
	Surface Water		
1	A tidal flat on ocean side	1060	483
2	Taylor's Creek (sound)	1014	477
3	Tidal lake (connects with sound)	718	339
	Water Holes		
4	Hole dug by ponies approximately 50 feet inland from 1, *ca.* 4 feet deep	5	<10
5	Hole dug by ponies in middle of Carrot Island, *ca.* 4 feet deep	193	68
6	Hole dug by W.B.B. approx. 10 feet from 3, *ca.* 3 feet deep	7	<10

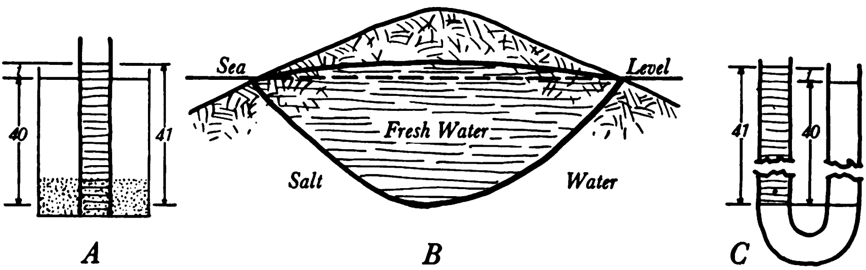


FIG. 5. Diagram illustrating the Ghyben-Herzberg principle. See text for explanation.

Once again, it can be seen that the osmolality of the water obtained from the holes is quite low.

I was amazed and mystified by the findings and therefore consulted Doctor Daniel Okun of the Sanitary Engineering Department of the School of Public Health at the University of North Carolina.

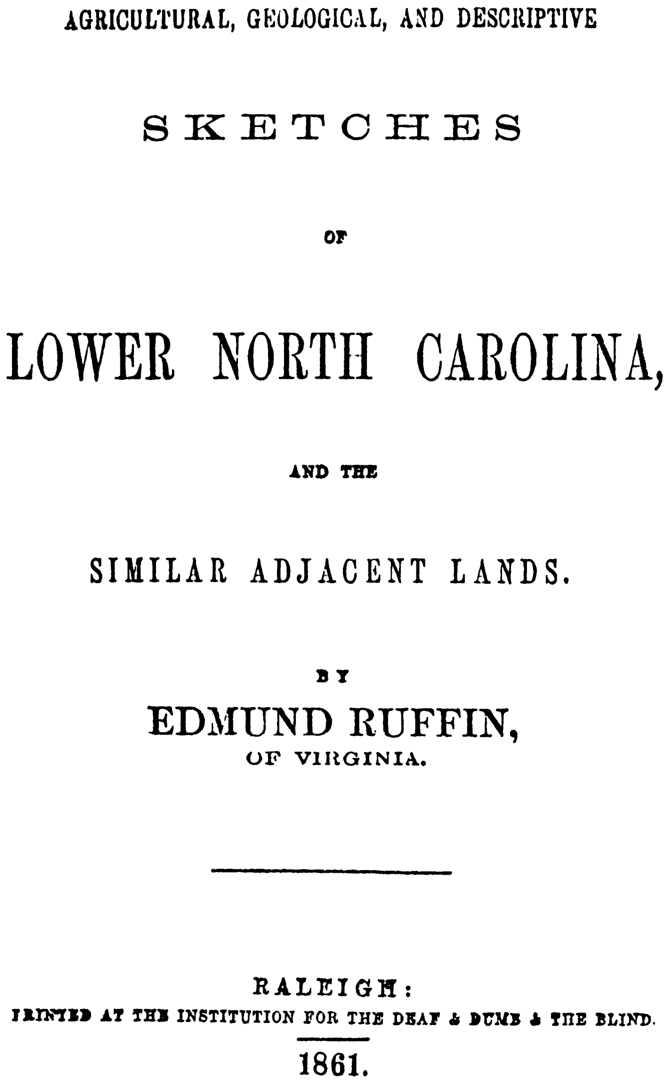
As is often the case when one is informed, Doctor Okun was not amazed and saw no mystery in the findings.

He told me that they were explained by the Ghyben-Herzberg principle.

The Ghyben-Herzberg principle, named for its originators, two Dutchmen, is concerned with the forces controlling the relationship between fresh water and salt water on islands and peninsulas, surrounded by or near the sea.

The principle can be illustrated by the ideal example of a circular island of permeable sand surrounded by ocean water and supplied with enough rainfall to develop a body of ground water in the sand (see Figure 5).

As is shown in the center of Figure 5 over B, under these circumstances, a lens-shaped body of fresh water occurs and floats on—and in equilibrium with—depressed sea water, much as an iceberg floats in the ocean with most of its mass submerged. Why this happens is illustrated in A and C. First, A. This is a beaker with sand at the bottom and filled with sea water. In your minds, place in the center an open-bottomed tube filled with fresh water. Because fresh ground-water is 40/41 as heavy as sea water, the fresh water will stand 41 units high while the sea water



AGRICULTURAL, GEOLOGICAL, AND DESCRIPTIVE

SKETCHES

OF

LOWER NORTH CAROLINA,

AND THE

SIMILAR ADJACENT LANDS.

BY

EDMUND RUFFIN,

OF VIRGINIA.

RALEIGH:

PRINTED AT THE INSTITUTION FOR THE DEAF & DUMB & THE BLIND.

1861.

FIG. 6. Title page of book by Edmund Ruffin in which he describes how the banker ponies obtain fresh water.

will be 40 units. This is also illustrated in C with a U tube—with fresh water on your left. Thus, for every foot that fresh water in such a system stands above sea level, it extends 40 feet below sea level.

During rainy seasons, the water table rises and the bottom of the lens therefore sinks, and the converse occurs during periods of drought.

Several conclusions may be drawn from the study. First, it is clear that fresh water is available to the banker ponies. Second, the ponies drink the fresh water. How much they drink—and how much sea water they drink—remains unknown. It seems likely that they must have a high intake of sodium chloride since much of their grazing is in tidal flats which is under sea water at high tide. I hope to be able to investigate the extent of their salt intake.

It seems likely that the practice of digging holes for fresh water is learned behavior, but how the first ponies learned that fresh water is available underground is a mystery. It is doubtful that they knew of the Ghyben-Herzberg principle.

Furthermore, their practice has been known of by some observers for at least 121 years. In 1861, Edmund Ruffin, of Virginia, in his book entitled *Sketches of North Carolina and the Similar Adjacent Lands* (4) wrote this of the matter (Figure 6):

"On the whole reef, there are no springs; but there are many small tidewater creeks, passing through and having their heads in marshes, from which their sources ooze out. Their supply must be from the overflowing sea-water. I could not learn and do not suppose, that these waters, even at their highest sources, are ever fresh. Water that is fresh, but badly flavored, may be found anywhere (even on the sea-beach), by digging from two to six feet deep. The wild horses supply their want of fresh water by pawing away the sand deep enough to reach the fresh-water, which oozes into the excavation, and which reservoir serves for this use while it remains open".

ACKNOWLEDGMENT

I thank Doctor Joseph Bonaventura and the personnel of the Duke University Marine Laboratory for their help in the study.

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DISCUSSION

Schreiner (Washington): Bill, as a thirty year tourist on the outer banks, we long ago learned that the way to get a well was to simply pound a pipe down about 8 feet next to the house and one of the curious things we find every couple of years or so is, some northern city boy coming down and deciding that he's going to get better tasting water by drilling a well very, very deep and, of course, because of your lens shaped thing, it always turns out to be salty and they come knocking at my door asking if they can borrow some water to mix with their scotch or bourbon. But it's very simple and we just move the points. On the average, even from the house sites which go through dunes, it's 8–10–12 feet, so it fits your theory very nicely.

Blythe: Of course, one of the problems nowadays is that as people move into these areas they really are decreasing the size of the lens as they pump the fresh water out. Ponies don't have the problem of obtaining salt water when they dig holes. They've never dug that deep to my knowledge.